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alaska's fishery resources - - -

the pacific herring

GERALD M. REID

NMFS Extension Publication

SEATTLE, WA
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ALASKA'S FISHERY RESOURCES

THE PACIFIC HERRING

GERALD M. REID

Fishery Biologist[1]

ABSTRACT

The Pacific herring, *Clupea harengus pallasi*, is a valuable natural resource in the coastal waters of Alaska, not only because of its direct commercial significance but also because of its importance as a component in the complex food cycle of other commercially valuable fishes.

Pacific herring are indigenous to the North Pacific rim and are closely related to the herring of the Atlantic Ocean.

Pacific herring generally spawn on intertidal vegetation in the spring. Although spawning is often successful in terms of density, subsequent mortality of eggs and larvae may exceed 99%.

Herring abundance fluctuates greatly. Biologists have attempted to understand and predict fluctuations by studying changes in the numerical strength of different year classes of herring taken by the commercial fisheries.

Commercial utilization of Alaska herring by American fishermen is at a low level because of various socioeconomic problems, although thousands of tons were taken in the past for food and industrial products. Foreign vessels are currently taking large quantities of herring in areas offshore from Alaska. A viable herring industry might develop if an economical method of producing fish protein concentrate from fatty fish is developed. Alaska herring reduced to the concentrate could provide an essential item in the diet of peoples of protein-deficient nations.

INTRODUCTION

The Pacific herring, *Clupea harengus pallasi,* (Fig. 1) occurs in most coastal waters of Alaska and is important not only for human food and industrial use but also as an element in the complex predator-prey relationship of the marine environment. Sitka and

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Craig, and perhaps other towns in Alaska, originated from native Indian villages that had been established close to herring spawning grounds simply because the herring provided a dependable source of food for the inhabitants. Even greater than its use by man for food has been the use in the past of Alaska herring in the manufacture of industrial products—thousands of tons were reduced to meal for animal food and to oil for diverse industrial applications. The place of the Alaska herring in the natural food pyramid is a further manifestation of the value of this natural resource. Herring feed on plankton and are in turn eaten by larger fishes, particularly salmon and halibut.

Fishing for herring on a large scale began about 1900, and a flourishing fishery soon developed. World War I stimulated the demand for salted and pickled herring, which resulted in an annual production of thousands of tons of these products. Manufacturing of salted and pickled herring began to decline in the mid-1920's because of a drop in the domestic demand and competition from east coast and foreign producers. The market for industrial herring products gradually increased, however, and in 1937, 113,000 metric tons of Alaska herring were used in the production of fish meal and oil. Currently, the world's requirements for meal and oil are expanding. The Food and Agriculture Organization of the United Nations reported that in 1953 production of fish meal from all producing countries was about 1.1 million metric tons. The average output of the world's leading fish meal-producing countries from 1965 to 1969 was 2.1 million metric tons. Yet, paradoxically, the Alaska herring meal and oil industry

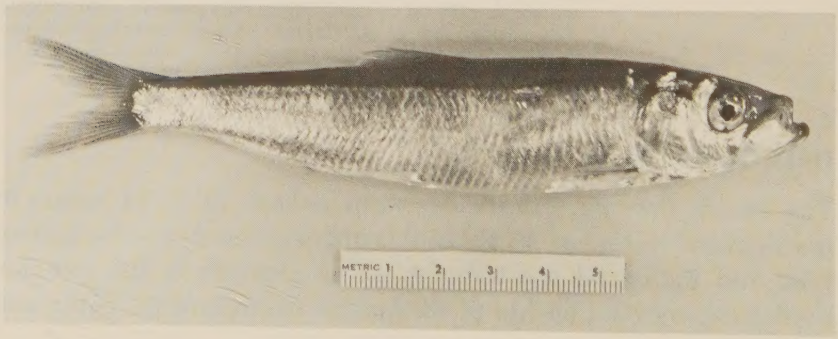

Figure 1.—The Pacific herring, *Clupea harengus pallasi.*

has failed because increased foreign competition, high labor costs, and restrictive fishery regulation by the State of Alaska have made the manufacturing of meal and oil uneconomical. Today, the few remaining Alaska herring processing plants stand idle, even though the resource is as healthy as ever and the industrial demand for herring products is the greatest in history. The small country of Peru has become the foremost fishing nation of the world, mainly on the strength of her production of meal and oil, manufactured from the anchovetta, a fish similar to the Alaska herring.

The habits and life history of herring have been studied extensively because of the fish's importance as an industrial resource, as a forage species for larger food fish, and as a predator on the young of other valuable species of fish. Although gaps in our knowledge still exist, much is known about the herring and the part it plays in the marine ecological system. Following is a brief resume of the life history, population dynamics, and economic importance of the Pacific herring in Alaska. For further reading, a list of selected references is given at the end of this report.

BIOLOGICAL CHARACTERISTICS

In general all Pacific herring have similar characteristics, although minor differences may exist between the herring in Alaska and those in other areas. They grow to lengths of 13 inches (33 cm), but an average large specimen is 9 or 10 inches (23 or 25 cm) long and weighs about one-third pound (150 g). They are bluish green on the back and silvery on the sides and belly and are covered with relatively large scales, which are easily dislodged. Herring are fast swimmers and occur in schools of up to 1 million or more fish. They feed principally on planktonic crustaceans and store large quantities of oil in their bodies. The common maximum life span is about 9 years, but some fish may live more than 15 years. They attain sexual maturity in their third or fourth year of life and spawn each year thereafter. A female can produce about 10,000 eggs when she is 3 years old and as many as 59,000 when she is 8.

Pacific herring differ in several respects from their close relatives, the Atlantic herring, *Clupea harengus*, which are found in the northwestern Atlantic Ocean and along the coasts of Europe and Scandinavia. The major differences between the two species are number of vertebrae, season of spawning, type of spawning ground used, and distance covered in their annual migrations.

DISTRIBUTION

Pacific herring occur all around the North Pacific rim, in the Bering Sea, and along the shores of the Arctic Ocean. They range along the Asian coast from the mouth of the Lena River in northern Russia to the west coast of Korea, and along the American coast from near the MacKenzie River in northern Canada to San Diego Bay. To the west, commercially valuable concentrations occur near northern Japan, the Okhotsk Sea, and the northeast coast of Kamchatka. In Alaska the largest commercial quantities occur around Kodiak Island in Prince William Sound, and in much of southeastern Alaska (Fig. 2). Recent developments in fishing techniques and gear have resulted in the discovery of additional concentrations of Pacific herring in the Bering Sea, where thousands of tons are now taken annually by Soviet (Fig. 3) and Japanese trawlers.

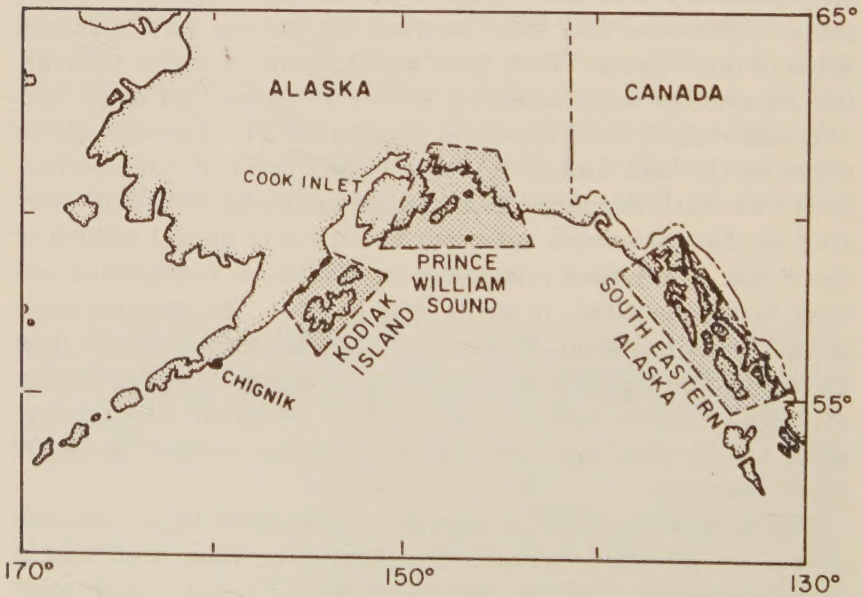

Figure 2.—Three major commercial fishing areas for herring in Alaska.

Figure 3.—Soviet herring trawlers in the Bering Sea.

LIFE HISTORY

The life history of Pacific herring from the time the adult fish spawn until the developing juveniles move from inshore waters is well documented, but little is known about what occurs in the 2½ years while the herring are growing to maturity.

Spawning

Pacific herring normally spawn in the spring each year after they reach sexual maturity. In Alaska they generally spawn for the first time in their fourth year of life. The older and larger females produce more eggs than the younger ones, but on the average, a female produces about 20,000 eggs per spawning. The eggs are adhesive and the female deposits them on solid surfaces rather than broadcasting them loosely in the water. The generally preferred surface for spawning is living plants, and those most often used are eel grass, *Zostera*; rockweed, *Fucus* (Fig. 4); and sea girdle, *Laminaria*. If a great many spawning herring are present, eggs may be deposited on almost anything. For centuries the Tlinget Indians of southeastern Alaska have capitalized on this behavior in collecting herring eggs for food. The Indians place

Figure 4.—Herring spawn on rockweed, *Fucus*. Herring in center was trapped in a tide pool and died.

tree boughs in the water at spawning areas (Fig. 5), and the fish deposit their eggs in layers on the branches (Fig. 6). The eggs can be easily stripped from the branches and eaten immediately, or they can be dried on the boughs and stored for future use.

The behavior of male herring during spawning can be used as an aid in determining the number of eggs deposited by the females. A spawning female makes physical contact with the substrate and lays her eggs on it in narrow bands; the male herring, who does not pair off with any particular mate, wanders among the spawning females extruding milt at random. The thousands, or perhaps millions, of fish spawning on a beach produce so much milt that the water becomes discolored. The extent of the discoloration

Figure 5.—Spruce boughs placed in water at low tide for herring to spawn on.

Figure 6.—Spruce boughs covered with eggs deposited by spawning herring.

can be observed from aircraft several miles away (Fig. 7), and biologists flying over spawning areas have used this characteristic to determine the limits of shoreline spawning. By combining the information from aerial surveys and counts of eggs obtained from samples taken on the beaches, the total number of eggs can be estimated.

Although the eggs produced and the numbers of fish producing them can be estimated from data gathered on spawning surveys, the number of herring that will survive to the adult stage from a particular spawning cannot be estimated. A heavy spawning may or may not result in more adult herring than a relatively light one. Some biologists believe that because of the mortality caused by crowding of the eggs, heavy spawnings may actually produce fewer young herring than moderate ones. Moreover, if many of the eggs of a heavy spawning hatch successfully, high mortality may result as the millions of larvae compete for a limited food supply.

Figure 7.—Aerial view of water discolored by milt of spawning herring near Japonski Island in Sitka Sound. The herring spawning occurred between the islands in the center of the photograph.

Eggs

The eggs of Pacific herring are small (1.0-1.5 mm in diameter), spherical, slightly heavier than seawater, and adhesive. They hatch after incubating for 12 to 20 days. The incubation time is governed by the temperature of the water—higher temperatures accelerate development. Even under ideal conditions, millions of the eggs fail to hatch and mortalities in the egg stage can range from 50% to as high as 99%. During the incubation period, eggs laid within the intertidal area are alternately exposed and covered by tides. If the weather is warm and clear, great numbers of these eggs may dehydrate and die in the sunlight when they are exposed by low tides. If the weather is stormy, severe mortality may result when the egg-covered eel grass or kelp is torn from the bottom and cast high up on the beach. The alternate exposing and covering of the eggs by the tide makes them available to both aquatic and terrestrial predators such as snails, crabs, fish, ravens, ducks, and other birds, and sometimes man.

Larvae

A herring larva bears only a slight resemblance to an adult herring. The larva is almost transparent, about one-fourth of an inch (6 mm) long, and a very feeble swimmer. At first a larva is unable to feed and must rely on a small quantity of yolk that remains in the egg. In a few days, all the yolk is used and the larva begins to feed. The transition from subsisting on the yolk to active feeding is perhaps one of the most critical periods in the life of the herring, for if the right kind and proper size of food is not readily available, the larva soon becomes so weak that it cannot capture food and will quickly starve to death. If water currents are unfavorable, thousands of larvae may be swept out to sea or to areas without proper food. Larvae are constantly exposed to predation by mahine animals such as arrow worms, comb jellies, and other fish. The mortality from predation may be especially heavy during certain years. In fact, the total mortality of larvae immediately after hatching may exceed 99%.

Juveniles

Metamorphosis—the change from a naked larva to a scaled juvenile—takes place 6 to 8 weeks after the egg is hatched. At this stage the young herring is 2½ inches (65 mm) long and resembles a miniature adult. The metamorphosed young collect

in small schools and gradually move seaward toward the mouths of the bays and inlets in which they were hatched. During this period they grow rapidly and consolidate into large schools. By early fall they are about 4 inches (100 mm) long and are in schools of perhaps 1 million fish or more. Most of the schools move into deep or offshore water by late fall. When they return 2½ years later as adults ready to spawn for the first time, they are 6 to 7 inches (150 to 180 mm) long.

POPULATION DYNAMICS

Biologists use the term "population dynamics" to describe the study of changes in animal numbers as related to births and deaths. It is a complex science when it deals with undisturbed populations, and becomes even more complicated when man enters the picture, either to harvest the population or to change its environment. We know little about the mechanisms that regulate the number of individuals in most animal populations. For instance, the abundance of adult herring in the ocean fluctuates in a yet unpredictable manner that is seemingly unrelated to the number of young produced or adults removed by fishing. Pacific herring are not unique in this respect—many other fishes the world over experience similar unpredictable highs and lows in their abundance. The random character of fluctuations in herring abundance makes it extremely difficult to predict accurately what the supply of fish will be from one year to the next.

One aid to understanding fluctuations in the herring supply is to observe the age composition—the numbers of herring of different ages that appear in the fishery each year—of the catches over the years. The age of a herring can be determined because herring scales increase in size with growth of the fish and reflect periods of rapid and slow development by forming rings or "circuli" in much the same manner that growth rings are formed in trees. The age of a herring can be determined by counting the annual rings on the scales. The herring is age I at the end of its first year of life when it has one annual ring on its scale. Figure 8 shows a typical scale from a herring age IX.

To gain an understanding of the manner in which fluctuations in herring abundance occur, the ages of herring in samples from the commercial fishery are determined. The percentages of herring of ages II through IX in the southeastern Alaska commercial fishery each year from 1954 to 1966 are shown in Figure 9. The fish

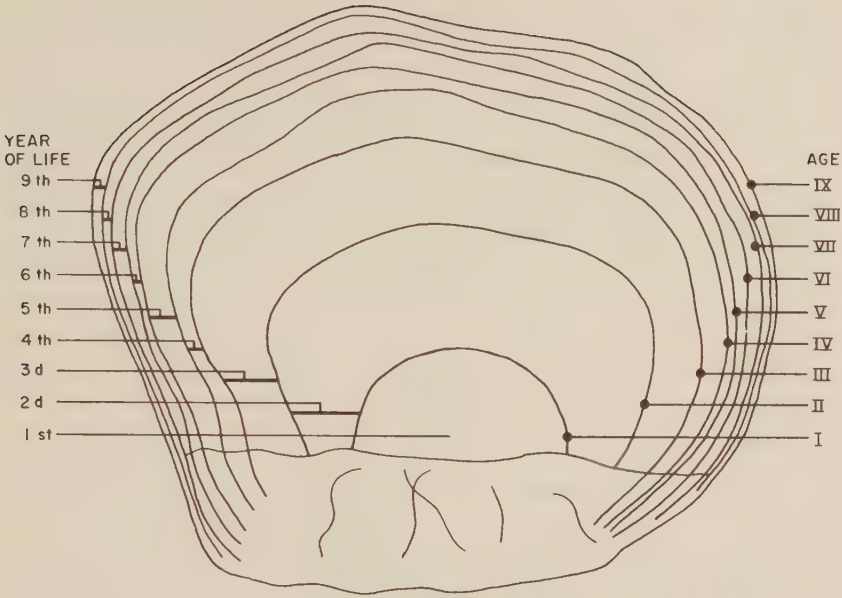

Figure 8.—Drawing of a typical scale from a herring, age IX.

born in a particular year are referred to as a "year class." Figure 9 shows the progress of a year class from the time it first appears in the fishery, when the herring are age II or III, until it disappears from the fishery.

The year classes 1953 and 1958 tended to dominate the southeastern Alaska fishery for several years in a row. These two year classes probably had better survival as young fish than those year classes which show consistently low percentages in the yearly catches, e.g., 1955 and 1956 (Fig. 9). The age composition data in Figure 9 show only the relative abundance of each age in the catch each year and tell nothing about the actual numbers or weight of fish caught.

To determine the relation between the abundance of a year class in the catch and the relative number of fish in the population, we must know the total number of fish caught, the age structure of the catch, and the amount of effort involved in capturing the fish. A particular year class may be relatively abundant in the catches during a fishing season, but the actual number of fish of the year class may be too few to yield a profitable catch. To determine the relative abundance of a year class during its life in the fishery (generally 5 or 6 years), it is necessary to record the number of

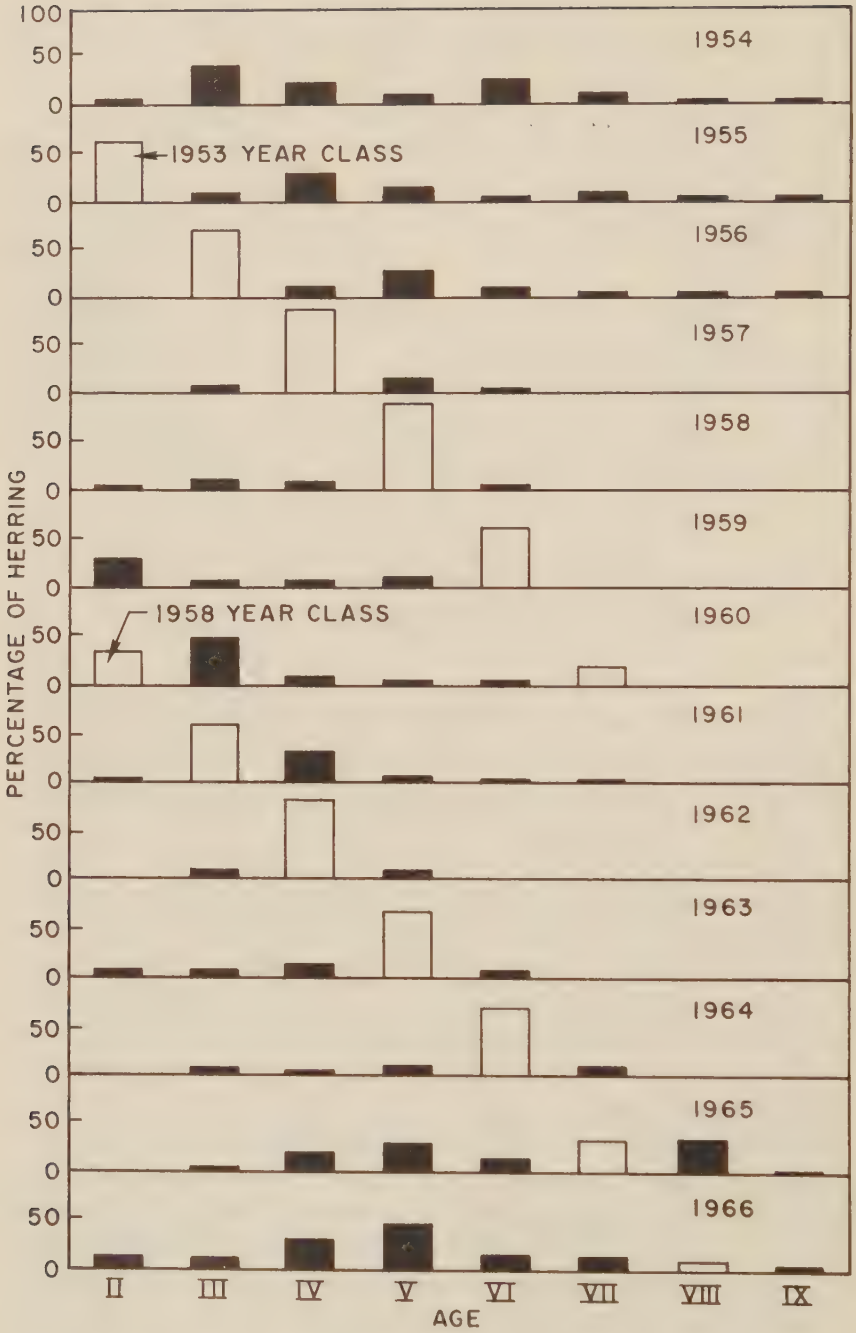

Figure 9.—Percentage of herring in each age class, II through IX, in southeastern Alaska commercial fishery from 1954 through 1966. The white bars represent the two major year classes, 1953 and 1958.

boats and fishing days required to make the catch for each year that the year class appears in the fishery. The relative abundance or "strength" of a year class over its mature lifetime then can be estimated by summing the number of fish of that year class caught per unit of effort (1 boat fishing 1 day) each season.

1950-58 in southeastern Alaska is shown in Figure 10. The survival of the 1953 and 1958 year classes was apparently high, as shown by the substantial contribution of those year classes to the

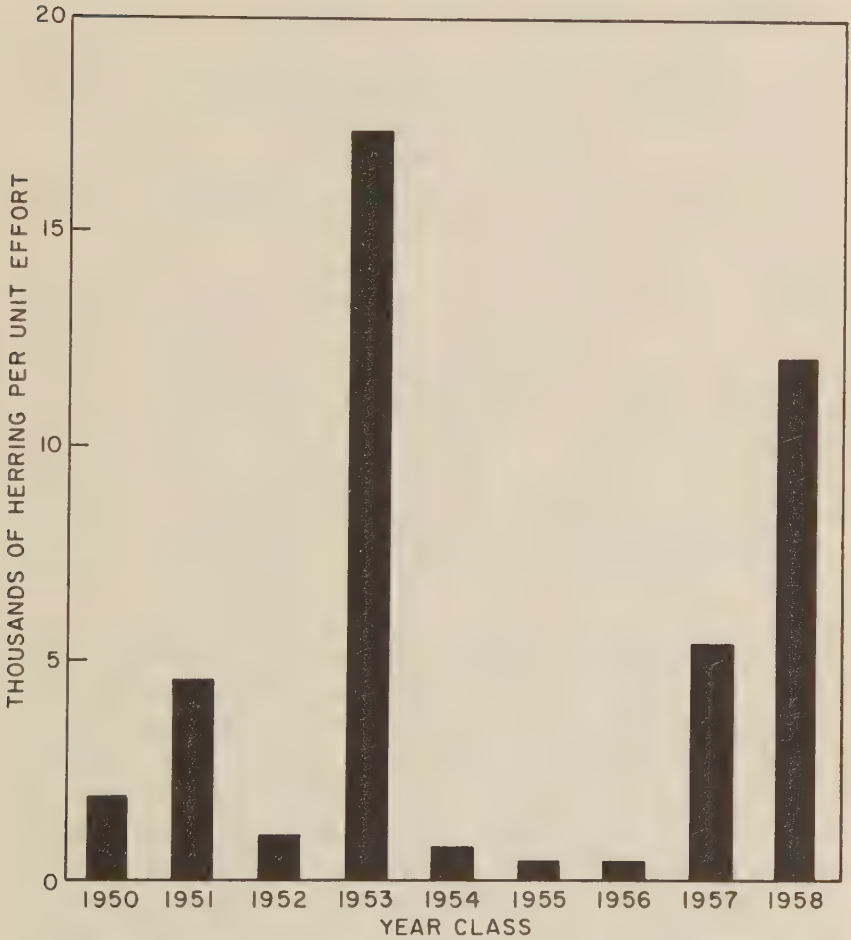

Figure 10.—Relative abundance of year classes 1950-58 for herring from southeastern Alaska commercial fishery, in terms of number of fish per unit of effort. Year classes are summarized over the life of the herring in the fishery (5 or 6 years).

fishery, whereas the survival of the 1955 and 1956 year classes was much less, as indicated by their relatively small contribution to the fishery.

Data on relative abundance are of value for predicting the number of herring that will be available, because year-class strength is usually apparent shortly after the fish first enter the fishery. The probable potential contribution of a year class to the fishery for its entire lifetime can be estimated by comparing the rate of catch of that year class at ages III and IV with similar data from preceding year classes.

COMMERCIAL FISHERIES FOR HERRING

The commercial fishery for herring in Alaska began in the late 1800's and since then has supported four distinct types of industry —the manufacture of fish meal and oil, salting and pickling of fish, preparation of the whole fish for bait, and processing of the eggs, or roe. Only the bait and roe industries are now active in the State.

The reduction fishery—the catching of the herring plus the process of manufacturing them into meal and oil—was an important industry in Alaska between 1882 and 1966. The fishery captured schools of feeding fish from June to September in inshore waters. The fish were most often caught in purse seines (Fig. 11) fished from boats 70 and 100 ft (21 and 30 m) long that carried crews of eight or nine men. Some of the purse seines were as large as 25 fathoms (46 m) deep and 250 fathoms (460 m) around the float line. A single set or casting of one of these giant nets could take as many as 700,000 to 900,000 fish (about 100 metric tons). Herring schools near the surface were located by a lookout stationed in the crow's nest of the vessel. In later years schools in deeper water were located by echo-sounding equipment. Several areas became known for the concentrations of herring occurring there, such as Cape Ommaney in southeastern Alaska and MacLeod Harbor in Prince William Sound (Fig. 2).

The first herring reduction plant was built in 1882 in Killisnoo on Chatham Strait, southeastern Alaska, at the site of an old whaling station. Fish meal manufactured at this plant was used for fertilizer. The use of herring meal as a fertilizer soon declined because of the development of cheaper chemical fertilizers, but an accompanying increase in the use of fish meal as a food additive for livestock and poultry supported the market for the Alaska product. Workers in the poultry industry found that feed-

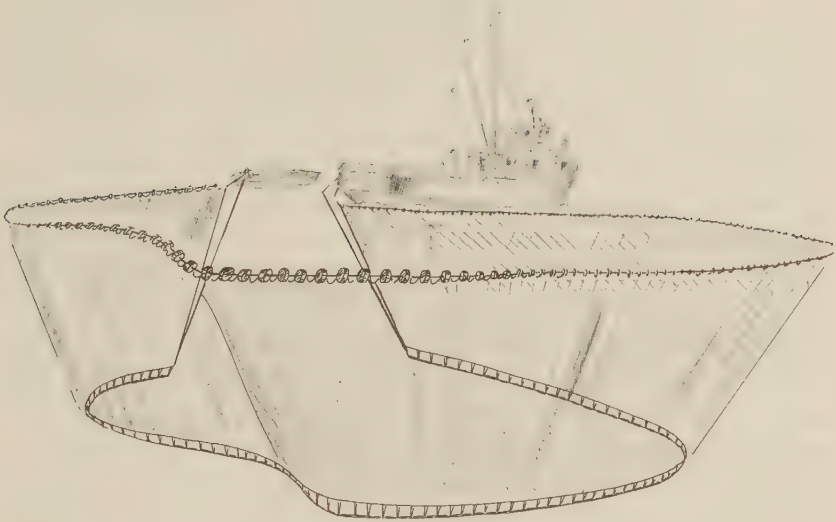

Figure 11.—Simplified sketch of herring purse seine and boat.

ing diets that contained high-protein fish meal greatly shortened the time necessary to grow marketable birds.

Herring oil, the other major product of the reduction fishery, has always been in demand because like many other fish oils, it contains substantial levels of long-chain, polyunsaturated fatty acids. These fatty acids make the oils highly desirable for certain industrial processes because they have superior lubricating, detergent, and plasticity properties. Among the many products utilizing herring oil are printers ink, paints, cosmetics, tanned leather, and oleomargarine (for export).

The greatest annual production of herring meal and oil in Alaska was in 1937, when 72 boats and 17 plants (Fig. 12) processed more than 251 million lb. (113 million kg) of herring. After 1937 the industry went into a general decline which eventually resulted in the cessation of herring reduction in Alaska. The last year of operations in Prince William Sound was 1958 and in Kodiak, 1959. The reduction industry in southeastern Alaska came to an end in 1966, when the last remaining boats and a single plant ceased operations.

The commercial production of salted and pickled herring, once a large industry in Alaska, ended in 1953. The industry began in 1894 with the preparation of about 46 metric tons of salted

herring. This early product was poorly prepared and difficult to sell, but an improved salting technique, called the Scotch cure method, was introduced by the U.S. Bureau of Fisheries in 1917. The improvement in quality plus a rising demand for food during World War I stimulated the industry to a peak production of 16,000 metric tons in 1922. Production leveled off to an average of about 6,600 metric tons per year until 1936, when an unfavorable market began to force some processors out of the industry and forced others to enter the burgeoning meal and oil business. By 1942, the production of pickled and salted herring was down to only 300 metric tons. A slight increase occurred during and immediately after World War II, and the average annual production between 1943 and 1947 was 792 metric tons. Only 250 metric tons were prepared in 1948, and production declined rapidly until 1953, the last year that Alaska herring were commercially prepared for eating purposes. In that year, only 775 lb. (338 kg) of herring were salted.

The commercial bait fishery in Alaska has harvested about 2,100 metric tons of herring annually for the past 10 years. The fish are captured during the spring spawning season in small round-haul seines or traps. They are held alive in enclosures called "pounds" until they can be conveniently processed. Most of the herring for bait are frozen at cold storage plants and sold in 50-lb. (23-kg) blocks, although some pound operators hold live fish throughout the summer for sale to commercial and sport fishermen.

A commercial fishery for herring roe began recently in Alaska and involves two types of fisheries. In one, which is concentrated

Figure 12.—Herring processing plant, Big Port Walter, southeastern Alaska, where herring were reduced to meal and oil.

mainly in the Cook Inlet-Prince William Sound area but also occurs in southeastern Alaska and Bristol Bay, the sac roe (Fig. 13) is removed from fish captured just before they spawn. In the other fishery, which at present occurs in Prince William Sound and Bristol Bay, fronds of a certain type of kelp (*Macrocystis*) on which eggs have been spawned, are collected. The roe on kelp is usually preserved by heavy salting, although some processors freeze it without salt. Most of the products from the two fisheries are exported to Japan, where they are greatly esteemed and command high prices as a gourmet food. In 1970, Alaska production from the two herring egg fisheries was 95 metric tons of eggs-on-kelp and 300 metric tons of sac roe with a total value of $1.4 million.

The fishery for eggs-on-kelp is variable, in that the herring occasionally do not spawn on the marketable species of kelp. For instance, in southeastern Alaska where the fishery originated, no herring eggs were deposited on *Macrocystis* in 1969 and 1970. Both of the roe fisheries are closely regulated by the State of

Figure 13.—Workers in processing plant at Sitka, Alaska, removing roe from herring.

Alaska, and no substantial expansion of either of them is expected in waters under the State's jurisdiction. An expanding operation for sac roe, conducted by Japanese and Soviet factory vessels, exists in the offshore waters of the Bering Sea. Current production figures are not available for this fishery, however.

Our knowledge of the effect on the herring population of taking large quantities of eggs is extremely limited. We have not been able to establish a valid relationship between the number of eggs produced and the resulting adult herring. Limited spawnings have occasionally produced large year classes and heavy spawnings have sometimes resulted in small year classes. Considerable research is needed in the area of herring spawn-recruit relations in light of the increasing demand to harvest the eggs. Unfortunately, no research is now being done on herring in Alaska.

THE ALASKA HERRING INDUSTRY IN PERSPECTIVE

Only a fraction of the herring resource of Alaska is now being harvested. The only domestic harvests are the small bait fishery and the closely regulated operation for taking eggs. Major herring processing plants have not operated since 1966. The United States has no fisheries for herring in the Bering Sea, the Aleutian Islands, or the Gulf of Alaska. On the other hand, foreign fleets, principally those of Japan and Russia, have taken more than 450,000 metric tons of herring in 1 year from some of the areas on the continental shelf off Alaska. Other foreign fleets may soon be fishing near Alaska shores to a greater extent and may also harvest herring.

The market for Alaska herring meal and oil has been eliminated by high labor and transportation costs, competition by foreign products, and restrictive regulations imposed on the fishery. There is hope for improvement of the situation in Alaska, however. Worldwide demands for industrial fish products are strong and increasing. Recent declines in herring fisheries of the North Sea could stimulate interest in Alaska stocks for salted or pickled products, which could be exported to Europe. Even greater demands for fish ordinarily used for industrial products are anticipated when a more economical technique is found to produce foodstuffs from fatty fish. Need for animal protein by the world's exploding human population will soon require development of food

supplies from resources currently not used. In Alaska, the herring represents such a resource, and the reduction of this fish to FPC (fish protein concentrate) could help the Alaska fishery to reenter the world market and at the same time provide an essential item for the diet of peoples of protein-deficient nations.

PUBLICATIONS ON HERRING

The following annotated listing of publications will provide more detailed information for readers interested in specific subjects concerning both Pacific and Atlantic herring.

Blaxter, J. H. S., and F. G. T. Holliday. 1963. The behaviour and physiology of herring and other clupeids. *In* F. S. Russell (editor), Adv. Mar. Biol., p. 261-393. Academic Press, London.

Investigations into some behavioral and physiological responses in the gametes, eggs, larvae, and adult stages of herring and other clupeids.

Hodgson, W. C. 1957. The herring and its fishery. Routledge and Kegan Paul, London, 197 p.

An overall view of Atlantic herring life history, fishery, and population dynamics, with special emphasis on the East Anglian (Great Britain) stock.

Hourston, A. S. 1959. Effects of some aspects of environment on the distribution of juvenile herring in Barkley Sound. J. Fish. Res. Board Can. 16: 283-308.

Results of studies in Barkley Sound, British Columbia, on the distribution and abundance of larval herring in relation to water currents, temperature, salinity, food supply, and other factors.

International North Pacific Fisheries Commission. 1961. The exploitation, scientific investigation and management of herring (*Clupea pallasi*) on the Pacific coast of North America in relation to the abstention provisions of the North Pacific Fisheries Convention. Int. North Pac. Fish. Comm. Bull. 4, 100 p.

Papers presented to the International North Pacific Fisheries Commission over a period of 4 years, 1961-64, covering yield, effort, mortality rates, and other factors concerning Canadian and Alaskan herring in relation to abstention provisions of the North Pacific Convention.

Marti, Yu. Yu. 1956. The fundamental stages of the life cycle of Atlantic-Scandinavian herring. Polyarn. Nauchno-Issled. Inst. Morsk. Rybn. Khoz. Okeanogr., vyp. 9. Translated in Leslie W. Scattergood (editor), Herring of the north European basin and adjacent seas, p. 5-68a. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 327.

A detailed Russian study of Atlantic-Scandinavian herring life history including data on sexual behavior, growth, feeding, migration, and stock condition.

Nagasaki, F. 1958. The fecundity of Pacific herring (*Clupea pallasi*) in British Columbia coastal waters. J. Fish. Res. Board Can. 15: 313-330.
Results of a study on egg counts from British Columbia herring of different ages and from different habitats.

Parrish, B. B. (editor). 1963. Contributions to herring symposium, 1961. Cons. Perm. Int. Explor. Mer Rapp. P.-V. 154, 293 p.
A collection of papers presented at a herring symposium in Copenhagen in 1961 concerning current investigations of fishery-related problems for both Atlantic and Pacific herring.

Rounsefell, G. A. 1930. Contribution to the biology of the Pacific herring, *Clupea pallasii*, and the condition of the fishery in Alaska. U.S. Bur. Fish. Bull. 45: 227-320.
The first comprehensive report on the herring fishery and herring population dynamics in Alaska.

Scattergood, L. W. 1957. A bibliography of the herring (*Clupea harengus* and *C. pallasii*). Maine Dep. Sea Shore Fish., Res. Bull. 26, 108 p.
A complete listing of all readily available literature on Atlantic and Pacific herring.

Skud, B. E. 1959. Herring spawning surveys in southeastern Alaska. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Fish. 321, iv + 16 p.
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Countries are compared in relation to fish meal and oil production, prices, and governmental policies.

Taylor, F. H. C. 1964. Life history and present status of British Columbia herring stocks. Fish. Res. Board Can., Bull. 143, 81 p.
A general discussion of herring life history, population dynamics, management, and research in British Columbia.

This is the fifth in a series of publications that describe the fishery resources of Alaska.
The other publications and the species described are:

U.S. Fish and Wildlife Service Fishery Leaflet 619—The Pink Salmon
U.S. Fish and Wildlife Service Fishery Leaflet 631—The Shrimps
U.S. Fish and Wildlife Service Fishery Leaflet 632—The Chum Salmon
NOAA, NMFS, Fishery Leaflet 636—The Sockeye Salmon

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